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GEOMETRY DETECTED BY SHERLOCK HOLMES.

A few years ago I had a class of bad boys. One day in study period I found that the head gangster—one Tom—was reading a book. My first thought was one of joy,—"Peace at any price! Let sleeping dogs lie!" But I soon saw that Tom was watching me, to see if he could, as he would say, "put one over." All the other boys were on the watch too, furtively.

I let some time pass. Tom became so absorbed in his book he forgot to look at me. I began a slow tour around the room, drawing up finally in martial array in the rear of the enemy. The silence in that room cried aloud. Tom felt it and looked up.

"Give me the book, Tom!"

I glanced at it. It was a Sherlock Holmes story. Involuntarily, I exclaimed:

"That's a *good* story, don't you think so?"

"Yes, *ma'am.*"

"I'll put in on my desk. You can get it after school. Believe me, it will be all I can do to keep away from it, Tom. But I suppose the Board of Education is not paying me to read stories in school? Eh, Tom?"

Tom took the hint, got out his textbook and worked. The next morning he brought the book back to me, and mumbled shyly: "I read 'em all las' night. Thought p'r'aps you'd like to read 'em, too!"

I read that book with all my soul. This was the situation as I saw it. I had a gang on my hands; I was a new teacher. I must win them, or they would break me. How could I get hold of them? Evidently and best—through their interests, and the Sherlock Holmes detective story was one of these interests.

Curiously enough, these stories were founded on deductive reasoning and analysis,—and so is geometry. Why were they attracted to the one and repelled by the other? Were there any "identical elements," as the psychologist would say, that could be extracted and held up to the light? One might answer that the Holmes stories present a mystery, but it is equally evident that the same is true of some geometry problems,—as all parents will attest. And so the questions came to me: Can I take a Sherlock Holmes story and work it out mathematically? Can I take a geometry problem and work it out in Holmes' best style? Can I show that the reasoning, deductive in each case, is intrinsically the same? Can I thus use the detective instinct in a worth-while cause?

I turned to Mr. Holmes for pointers.

"Sherlock Holmes closed his eyes and placed his elbows on the arms of his chair, his finger tips together.

"'The ideal reasoner,' he remarked, 'would, when he is once shown a single fact in all its bearings, deduce from it not only all the chain of events which led up to it, but also the results which would follow it. The observer who has thoroughly understood one link in a series of incidents, should be able to state accurately all the other ones,—both the before and the after. We have not yet begun to grasp the results to which pure reason alone can attain. Problems may be solved in the study which have baffled all those who have sought a solution by the aid of their senses. To carry the art, however, to its highest pitch, it is necessary that the reasoner should be able to utilize all the facts which have come to his knowledge. This in itself implies, as you will readily see, a possession of all knowledge, which even in these days of free education and encyclopedias, is a somewhat rare accomplishment. It is not so impossible, however, that a man should possess all knowledge which is likely to be useful to him in his particular work, and this I have endeavored in my own case to do. If I remember rightly, Watson, you on one occasion, in the early days of our friendship, defined my limits in a very precise fashion.'

"Holmes smiled. 'Well! I say again that a man should keep his little brain attic stocked with all the furniture he is likely to use, and the rest he can put away in the lumber-room of his library where he can get it if he wants it. It is of the highest importance in the art of detection to be able to recognize, out of a number of facts, which are the incidental, and which the vital. Furthermore, it is an old maxim of mine, that when you have excluded the *impossible*, whatever remains, *however improbable*, must be the truth.'"

In brief, these are the three points Sherlock Holmes makes in his statement:

1. Marshal all related facts.
2. Select the essentials, by rejecting the incidental and by excluding the impossible.
3. Study the improbable.

With these guides in mind we are now in the position to study the "Boscombe Valley Mystery."* Briefly the facts are these: James McCarthy was found dying near the edge of Boscombe pool, a small pond nearly surrounded by trees, and about 300 yards from the road. His son gave the alarm, stating that he had heard his father cry out and had gone to his assistance, reaching him a moment before he died. On the ground near the pool were a gun, a large stone, and several footprints. The blow from which McCarthy died was on the back of the head.

Clearly now the gun, the stone, the footprints and the blow constitute the data or given. The murder is the result or conclusion. It becomes the detective's duty to connect cause and effect by an unassailable mathematically correct line of reasoning.

It is evident that there are two plans of attack—either on the cause, or on the effect. Let us consider first the data, and see what they have to tell us, and whither they lead us.

There are two possibilities—murder or suicide. Let us assume the man was murdered. In that case the gun might be the murderer's, or the murdered man's. The stone mentioned was lying on the grass—evidently brought to the pool—but by which one? The question looks hopeless so far; which way can we turn for more light?

The blow from which the man died was on the back of the head under the left ear. This points to the conjecture or hypothesis that it was given by someone from the rear, and that the implement of death was thrown by a strong hand, very likely the left one. But is it reasonable to expect the detective, in his effort to run down the criminal, to examine all the left-handed men in the world and get an alibi from each?

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* From "The Adventures of Sherlock Holmes," by Sir Arthur Conan Doyle.

What about the footprints? Do they lead anywhere? Examination reveals the fact that the left print is deeper than the right one. This argues that the murderer limped in his right leg. Must the detective discuss the question with all men who limp in their right legs?

What is the situation now? Let us put it into the form of a little chart.

Given:	gun	stone	blow	footprints
Immediate Conclusion	suicide	murder	given by a left hand	cripple in right leg

FIG. 1.

The data have all been studied, much has been learned from them, but the detective has arrived at an impasse of insuperable difficulties. The survey is too broad. It is world-wide. It looks hopeless. And so indeed feel the boy and girl when confronted with a geometry problem. Though they know well what they have to work with, and know well what they want, they have not always sufficient imagination nor experience to penetrate the darkness that lies between the two, and thus make the necessary links in their reasoning. In their hopeless groping and waiting for the inspiration that does not come they lose courage and interest and "give up."

Let us, therefore, make our attack from the other end. Let us reason from effect back to cause. We can in this way greatly *restrict* our problem. We can, as said, reason from one effect to its possible immediate causes. According to Holmes, we shall marshal our facts, reject the impossible and incidental, and select an essential cause. Having found a plausible one, we shall consider it in its turn an effect, and search for the immediate causes leading to it. By repeating this process several times we shall eventually arrive at the first cause. Thus by the various stages of analysis we shall unravel the mystery. Having done this by analysis, we can reverse the process and build up the entire story or proof by synthesis.

The murdered man, therefore, became Holmes' first consideration, and his natural question was: "Who were the last people to see McCarthy alive?" Inquiry revealed these last witnesses to be an old man, a game keeper, a young girl, and a servant. Since their testimony *antedates* the murder, we can make a little *chronological* scheme, writing them first thus:

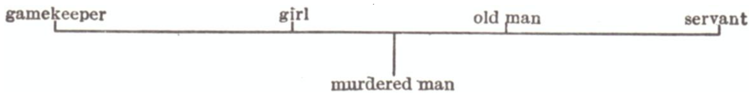

FIG. 2.

All the facts are now marshalled. The old man can be eliminated, as he could only say he saw McCarthy on the road. The gamekeeper and the girl said they saw McCarthy going toward the pool, but that they saw the son follow soon after. The servant said his master mentioned an appointment with someone but did not say where nor with whom.

Our scheme now looks like this:

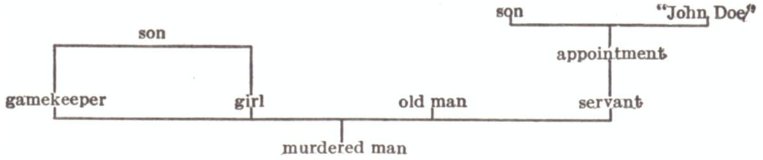

FIG. 3.

When questioned the son said that on that afternoon he intended calling at a house some distance down the road that led past the pool. When nearly opposite to it, he heard the call "cooee," which was the signal he and his father used to call each other. He went over, talked with his father, who seemed surprised to see him and to know that he had returned from the city. He had some words with his father and then went on his way. When he had passed the bend in the road and was out of sight of the pool he heard a cry. Thinking that harm had come to his father, he ran back, arriving just in time to hold the dying man in his arms and hear him say: "a rat." He did not know the significance of the word rat. The situation now is this: The son confesses a connection with the word "cooee," but denies any understanding of the dying man's last words. It is but natural that such words under such tragic circumstances would be of something relative to the murderer or to the manner of death.

At this point, therefore, it is only fair to keep an open mind concerning the son's probable guilt and to discuss the possibility of a stranger's having done the deed. Gathering up the threads our scheme now looks like this:

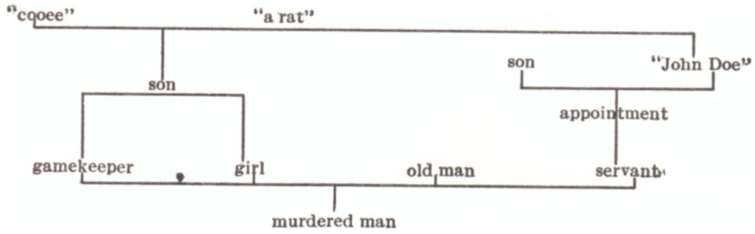

FIG. 4.

Holmes then stated that "cooee" is a well-known call among Australian miners; also that in Australia there is a town called Ballarat, and that it would have been a most natural thing for the dying man to have named his murderer as "so-and-so of Ballarat." "Cooee" and "Ballarat" thus point to an acquaintance whom McCarthy had known in his early days in Australia. Following this line of thought, there are two alternatives: Is the Australian acquaintance a neighbor or a visitor? Inquiry revealed the fact that there was a near neighbor by the name of Turner who had known McCarthy in the early days in Australia. So our chronological scheme is now like this:

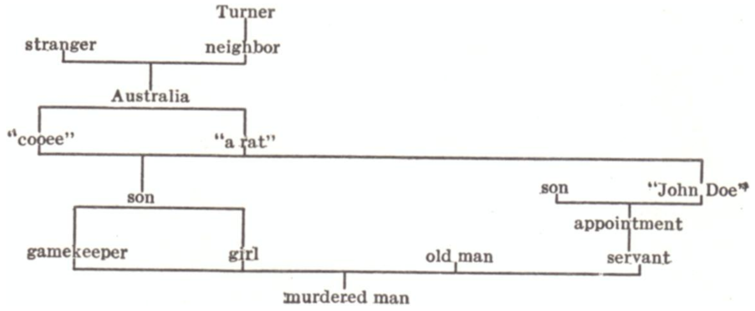

FIG. 5.

The next question is: "Does Turner check up in any way with the data?" The gun was proved to be McCarthy's from the evidence of the servant. The big stone might have been there several days, although the grass under it was still green. *But* Turner was a powerfully built man, used his left hand and limped in his right leg. All of our evidence can now be represented diagrammatically as follows, the complete synthetic proof developing along the route of the dotted line.

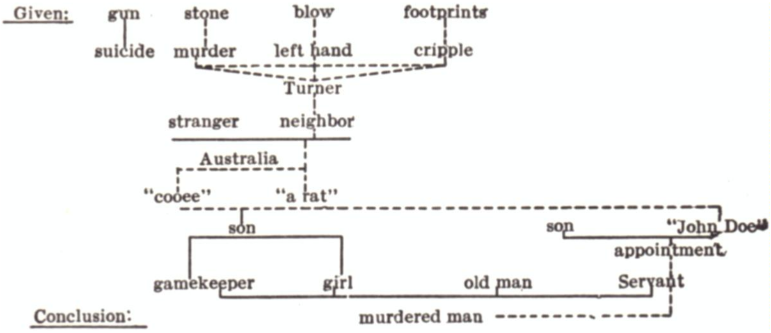

FIG. 6.

By analysis and by reasoning from effect to cause, Holmes arrived at the first cause. Reversing the process, and following the dotted line it is possible to build up the entire story synthetically. This exact process can be carried out in a geometry problem, and thus be made a "matter of transfer." In what follows notice that the three rules of Holmes are adhered to. *At every step* all the facts are *marshalled*, and *considered* as possible immediate causes. The *essentials* are selected through discussion, and by the rejection of some points that are incidental or impossible when considered in the light of the given. Lastly, the "*improbable*" proves to be probable because it checks up with the data.

In putting these schemes on the board, in the introduction to demonstrative geometry, it is best to write from the bottom up, building up the structure as each new step is found. When finished, if written in this way, the synthetic proof is in the proper order, and the pupil does not have to make a new orientation to state it in the usual form. This saves him from getting "mixed up," as he puts it.

Let us now proceed to solve a geometry problem by Holmes' own methods.

Given: An isosceles triangle ABC, in which CD is the altitude to AB, AE is the altitude to BC and $AE = CD$.

To prove: $\angle ACD = \angle CAE$.

Write the given at the top of the board or paper and the conclusion at the bottom—leaving the wide space between to be filled in. Since the immediate focus of attention is now on the conclusion, *i.e.*, proving the equality of two angles, the obvious and only question is: What situations produce equal angles? Experience and memory evolve a scheme in part like this:

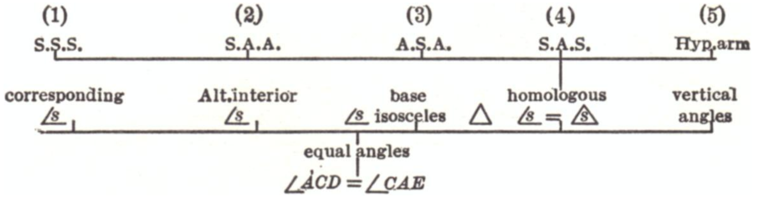

FIG. 7.

Discussion rejects (1) and (2) for the obvious reason that there are no parallel lines. A study of (3) and the drawing reveals the fact that the required angles are not the base angles of the given isosceles triangle, and though triangle AOC looks isosceles, there is no way of proving it so from our data. Also (5) is out of the question. Thus (4) appears to be the only way out—improbable though it may appear to the novice. The next question is, therefore: Under what conditions are triangles equal? The growing scheme on the board appears thus:

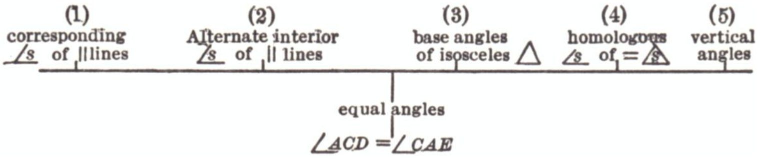

FIG. 8.

The comparison of the hypothesis and the triangles ACD and CAE with (1) discloses the fact that nothing is known concerning the third sides; while the examination of the drawing shows that the three elements required for the equality of the triangle are not arranged in the proper relation to admit (3) and (4). These elements, however, are arranged in the order of (2) or (5), hence it is readily seen that there are two solutions, and our scheme at this point, checking up with hypothesis, is as follows: We have come from conclusion to data, and can now reverse our steps, reading the synthetic proof as it develops along the dotted line.

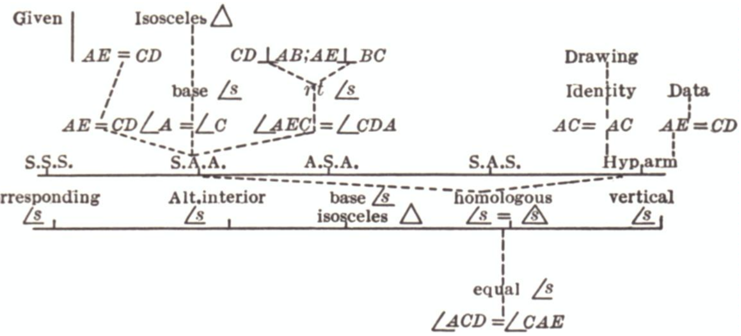

FIG. 9.

Space need not be taken here to write out the synthetic proof, as it is so easily seen by reading the diagram in the usual direction from the top down. This method of attack to a high degree removes vagueness and uncertainty, substituting a definite rule which invites progress. It furnishes a constant drill in the *organization* of thought as well as of subject matter and thus makes for clear thinking.

So much for the methods of the great detective. As for the man himself—the student's prototype—Dr. Watson, says: "Sherlock Holmes was a man, who, when he had an unsolved problem on his mind, would go for days without rest, turning it over in his mind, re-arranging his facts, looking at it from every point of view until he had fathomed it, or convinced himself that his data were insufficient."

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